HAZARDOUS WASTE REDUCTION
NAVAL AIR STATION-OCEANA

Elizabeth A. Clarkson
M.S. in Environmental Engineering.
Old Dominion University

MASTER'S REPORT
E. A. CLARKSON
June 1991

ABSTRACT

Hazardous Waste Reduction
Naval Air Station Oceana

This is a project to research Naval Air Station (NAS) Oceana's present operations in the area of hazardous waste controls from processing to disposal.

The research project was generated in response to NAS Oceana's requirement to meet and implement OPNAVINST 4110.2 [1] (dated 20 June 89). Areas of concern include waste management, regulatory compliance, and waste reduction. Waste reduction is seen as one key way to help NAS Oceana (and other naval bases) improve waste management by reducing liability, operational cost, disposal costs and environmental, health, and safety issues.

The Resource Conservation and Recovery Act places strict controls on the storage, treatment and disposal of hazardous waste. Presently, NAS Oceana has a disposal plan that is operational and complies with all associated regulations. This study addresses hazardous waste minimization through hazardous material reduction. This study proposes the use of innovative technologies and management practices to reduce the production/ generation of hazardous waste.

---

[1] Chief of Naval Operations instructions or directives are categorized and numbered by subject. The instruction OPNAVINST 4110.2 is titled Hazardous Material Control and Management (HMC&M). The purpose of this directive is to establish uniform policy, guidance, and requirements for the life-cycle control and total quality management of hazardous material acquired and used by the Navy. This instruction applies to all Navy organizations involved in the planning, procurement, acquisition, storage, distribution, use, or other disposition of hazardous material (including disposal of resultant hazardous waste).

OUTLINE

I. Introduction

A. Regulations
B. NAS Oceana Command Structure
C. Defense Reutilization Marketing Office (DRMO)

II. Problem definition

A. Sources and quantities of hazardous waste
B. Hazardous Waste generation, handling and disposal practices

III. Technology and Alternatives

A. Waste hydraulic fluids change out
B. Solvents
C. Waste paint and related material
D. Battery fluid acids
E. Other alternatives

IV. Cost analysis

A. Present operations and disposal cost
B. Recommended methods and substitutions
C. Savings

V. Recommendations for hazardous waste management

A. Waste hydraulic fluids
B. Solvents
C. Waste paints and related material
D. Battery electrolyte

VI. Summary

VII. References

VIII. Appendix

A. Acronyms
B. Glossary of terms
C. Manufacturer's Data

I. INTRODUCTION

A. Regulations

The magnitude of hazardous waste generation and the potential for environmental impact through improper handling and disposal continue to be defined. It is anticipated that stricter controls will be placed on the management of hazardous waste. The following is a brief description of the primary existing legislation dealing with hazardous waste.

1. Federal Legislation

Resources Conservation and Recovery Act (RCRA) of 1976 and the Hazardous and Solid Waste Amendments (HSWA) of 1984 form the foundation for the Federal regulatory program and provide overall guidance for the management for hazardous waste. They establish a comprehensive program to protect human health and the environment from the improper management of hazardous waste. The intention of this legislation is to regulate the handling of hazardous waste from "cradle to grave." States are given the opportunity to establish their own authority, but it must generally be patterned after the Federal program. The Commonwealth of Virginia has established its own program, but in general its requirements are the same as those of the Federal program.

Section 3001 of RCRA requires the U.S. Environmental Protection Agency (EPA) to promulgate regulation that identify hazardous waste by "characteristics of hazardous waste" and by the "listing of hazardous waste." The EPA established these regulations in Section 40 of the Code of Federal Regulation (CFR), Part 261. The characteristics of hazardous waste are ignitability, corrosivity, reactivity, and extraction procedure (EP) toxicity as defined in 40 CFR 261 (c). The lists of specific hazardous waste are provided in 40 CFR 261 (d).

Section 3010 of RCRA requires all persons managing hazardous waste to identify themselves and their hazardous waste activities to EPA. Section 3002 requires EPA to establish standards for generators of hazardous waste. A generator is one whose act or process results in hazardous waste generation. The generator must manage that waste in accordance with generator standards; manifests to track movement of the waste are required and the generator is restricted to utilizing transportation and disposal companies that have received an EPA identification number (40 CFR 262). Because many of the materials disposed of by the Public Works Department at NAS Oceana are hazardous, the installation NAS Oceana is required to notify EPA of its activities. The manifesting and transportation requirements must also be met.

Section 3003 of RCRA requires EPA to establish performance standards for transporters of hazardous waste. The U.S. Department of Transportation (DOT) regulations also mandate record keeping concerning delivery of hazardous waste shipments. EPA established these standards in 40 CFR 263.

Section 3004 of RCRA requires that EPA establish performance standards for facilities that treat, store, or dispose of hazardous waste. The EPA established interim performance standards in 40 CFR 265, and performance standards for new facilities are provided in 40 CFR 264. Both of these regulations establish general facility standards, contingency planning requirements, record keeping requirements, and design and operating criteria, as well as standards for closure and post closure. The standards for management of specific hazardous wastes are covered in 40 CFR 266.

Section 3005 of RCRA requires owners and operators of treatment, storage, and disposal (T/S/D) facilities to obtain a permit. Permits are not required by generators or transporters, although they must obtain an EPA identification number. The requirements for permit application were established in 40 CFR 270.

The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980 and the Superfund Amendments and Reauthorization Act (SARA) of 1986 provide authorization to the Federal government to remediate "hazardous substances" from active and inactive disposal sites and to assist in the cleanup of emergency spill situations. They also hold liable any person or organization who generates hazardous waste by making them a "responsible party" for any further problems with the waste they generate. This responsibility exists regardless of contractual arrangements with disposers or whether disposal at the time was in accordance with existing federal, state, and local laws, rules, and regulations. This liability provides additional impetus to the generator to reduce the volume of hazardous waste generated and requiring disposal.

2. State Regulations

The Commonwealth of Virginia has adopted regulations for the proper disposal of solid waste (Rules and Regulations of the Virginia Department of Health, Chapter XXVII, Disposal of Solid Waste, 1984). The major impact of this regulation is the definition of hazardous waste which is defined as materials which, because of their inherent nature and/or quantities, require special handling during disposal. Hazardous waste under this definition includes paints, acids, caustics, and chemicals. Under this regulation no hazardous waste may be disposed of in sanitary landfills.

Virginia's hazardous waste management regulations establish the

Commonwealth of Virginia's program for hazardous waste management. Under these regulations, the state has received authorizations to administer the requirements of RCRA/HSWA. The regulations promulgated by the Commonwealth of Virginia in regard to hazardous waste disposal are essentially the same as the federal laws and regulations.

B. Naval Air Station Oceana: Command Structure (and Sources of Hazardous Waste)

Naval Air Station (NAS) Oceana generates over 41,000 pounds of process and hazardous waste per year. The cost of handling this waste was approximately $209,000 for 1989. It is projected that these figures will increase by a factor of 3 over the next 7 years due to tightening of regulatory constraints. In order to fulfill Chief of Naval Operations objectives, NAS Oceana must implement a hazardous waste minimization program to reduce by at least half the amount of hazardous wastes it produces.

The Resource Conservation and Recovery Act (Federal Register, 1984) places strict controls on storage, treatment and disposal of hazardous waste. Naval Air Station Oceana has a working program that complies with all regulations for hazardous waste disposal. This study will address recycling options, hazardous material reduction by substitution, and reuse of discarded materials in less demanding applications.

Naval Air Station Oceana is made up of departments and tenant commands. Tenant commands are organizations that inhabit buildings & office spaces; use facilities (runways, parking, parks, antennas) and are provided services such as grounds keeping, trash removal, and janitorial; without direct expenditure of tenant command funds. The command structure is as depicted in Figure 1.

Aircraft Intermediate Maintenance Department (AIMD) produces hazardous waste from many of its maintenance shops:

SHOP	WASTE
Armament	cleaning solvents
Avionics Corrosion	paint thinners
Generator	engine oils
Ground support equipment	hydraulic fluids/freon
Radar	freon and heat transfer oils
Tire and wheel	solvents

NAVAL AIR STATION OCEANA COMMAND ORGANIZATION

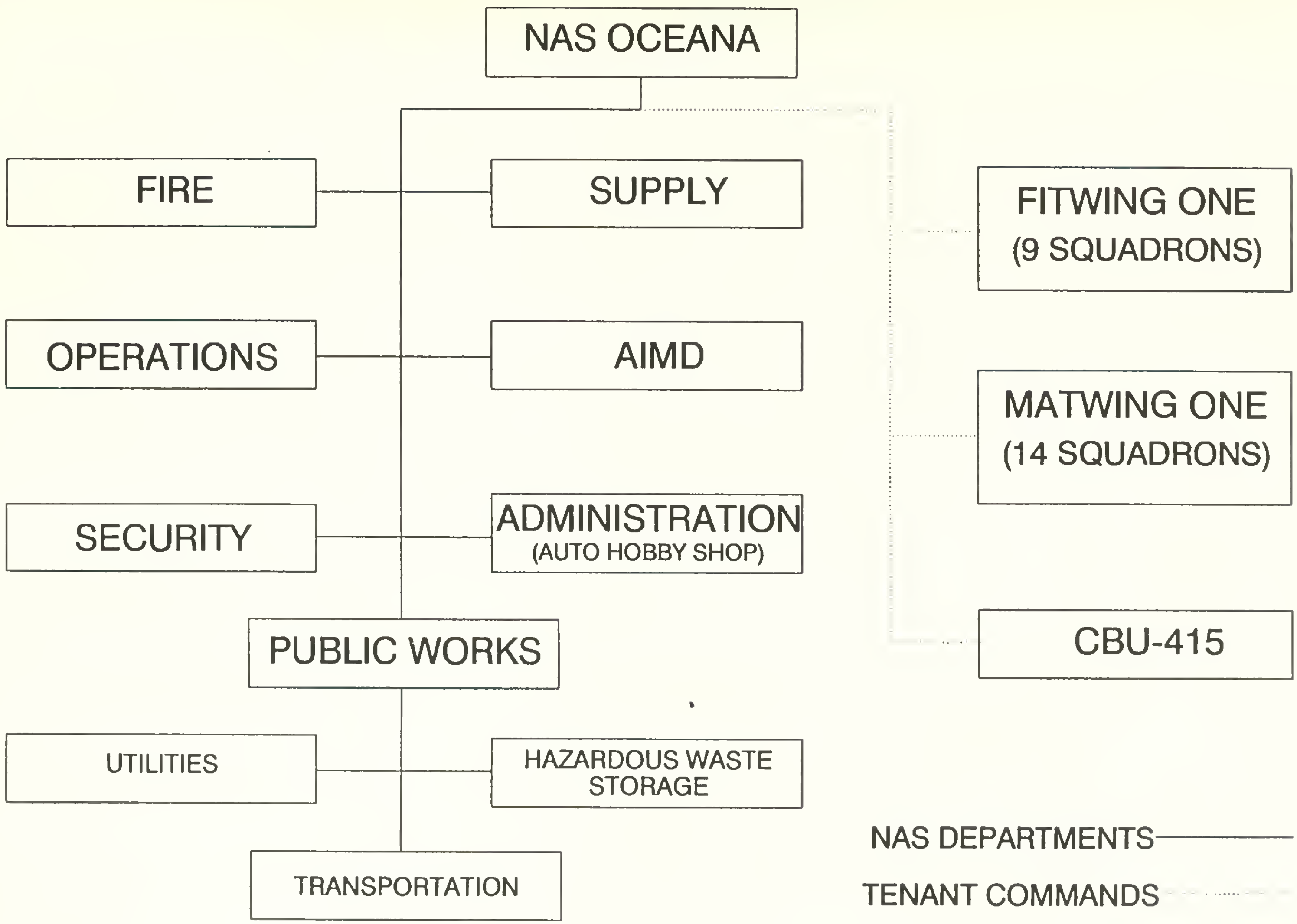
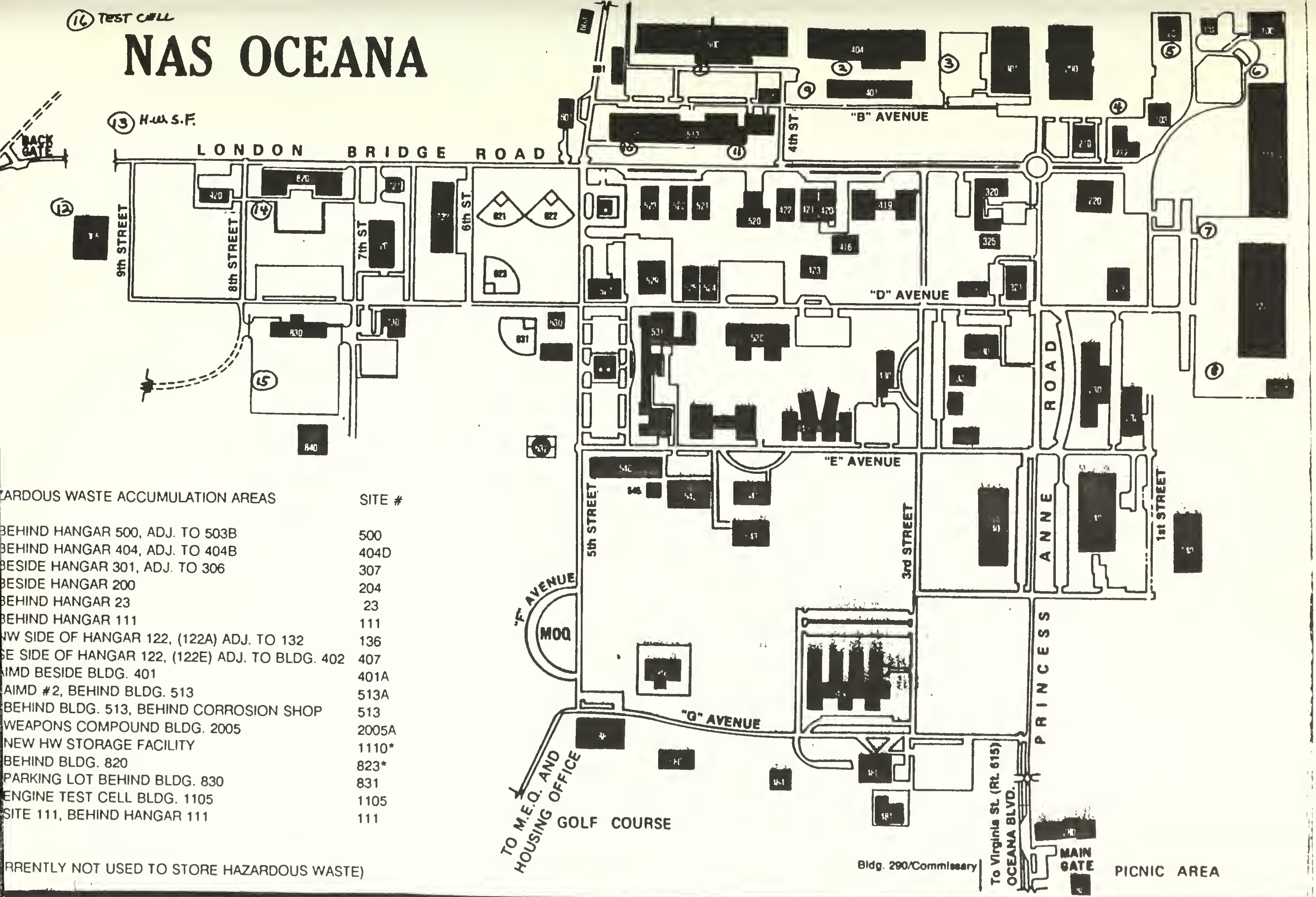


FIGURE-1.

NAS OCEANA



...ZARDOUS WASTE ACCUMULATION AREAS	SITE #
...BEHIND HANGAR 500, ADJ. TO 503B	500
...BEHIND HANGAR 404, ADJ. TO 404B	404D
...BESIDE HANGAR 301, ADJ. TO 306	307
...BESIDE HANGAR 200	204
...BEHIND HANGAR 23	23
...BEHIND HANGAR 111	111
...NW SIDE OF HANGAR 122, (122A) ADJ. TO 132	136
...SE SIDE OF HANGAR 122, (122E) ADJ. TO BLDG. 402	407
...AIMD BESIDE BLDG. 401	401A
...AIMD #2, BEHIND BLDG. 513	513A
...BEHIND BLDG. 513, BEHIND CORROSION SHOP	513
...WEAPONS COMPOUND BLDG. 2005	2005A
...NEW HW STORAGE FACILITY	1110*
...BEHIND BLDG. 820	823*
...PARKING LOT BEHIND BLDG. 830	831
...ENGINE TEST CELL BLDG. 1105	1105
...SITE 111, BEHIND HANGAR 111	111

...RRENTLY NOT USED TO STORE HAZARDOUS WASTE)

Aircraft Fighter Wing (FITWING) One has 14 squadrons and each has approximately 12 aircraft and several maintenance shops. Aircraft hydraulic fluid is tested with freon and the fluid is replaced when found to be contaminated. Solvents, paint thinners and anticorrosive materials are used by most shops to clean and treat parts and equipment.

Medium Attack Wing (MATWING) One produces the same wastes as FITWING for its 9 squadrons.

The hazardous waste from Public Works Department (PWD) is generated by the Transportation section (fuels & oils) and the Utilities section. Also PWD is the department which is responsible for collection and storage of all hazardous waste. The transportation, storage and ultimate disposal is handled by PWD in accordance with EPA requirements. In overseeing the entire program PWD trains personnel from other commands, prepares the manifests and coordinates the DRMO disposal contracts.

Other organizations, on base, contributing to the hazardous waste to be disposed are the Auto Hobby Shop, Fire Department, Construction Battalion Unit (CBU) 415 and the Supply Department. Most of the waste is fuel, oils, antifreeze, and cleaning solvents (trichloroethane). The material to be disposed from the Supply Department is that which has an expired shelf life.

Currently, the fifteen points established at NAS Oceana (Figure 2) are adequate to handle the hazardous waste generated.

C. Defense Reutilization Marketing Office, (DRMO)

This Department of Defense (DOD) agency is responsible for obtaining contracts to dispose or reuse all material discarded by all federal agencies. Items for reuse, resale or disposal include vehicles, furniture, office equipment, hazardous and nonhazardous waste, and other items.

When a generator, such as NAS Oceana, has sufficient volume to warrant removal, the generator notifies DRMO and requests collection. DRMO then issues an order to their contractor requesting collection and recycling. The contractor makes collection, prepares the manifest, and transports the waste to the point of recycling or disposal. If the recycled product is to be returned to the Navy, the contractor transports recycled product back to the point of distribution (NEESA, 1989).

II. PROBLEM DEFINITION

A. Sources and Quantities of Hazardous Waste at NAS Oceana

The major sources of hazardous waste generated at NAS Oceana are the Aircraft Intermediate Maintenance Division (AIMD), Fighter Wing One (FITWING), Medium Attack Wing One (MATWING), Public Works Department (PWD), and the Navy Exchange (NEX) Service Station and Auto Hobby Shop. The total annual volumes (for 1989) of some of the hazardous waste generated at NAS Oceana are shown below.

TYPE	VOLUME (lbs/year)
Hydraulic fluids (contaminated)	10,035
Cleaning solvents	4,950
Waste paints	4,055
Paint removers	3,770
Paint thinners	2,970
Propellant, (from aerosol cans)	2,506
Battery fluid acid	1,310
Solidified paint	1,224

This list includes only the eight materials which have the highest volumes. The total weight of all the hazardous waste that was disposed of in 1989 by PWD was 41,134 pounds per year. The cost of storage and disposal was $209,000 (NAS Oceana Annual Report, 1989)

B. Hazardous Waste Generation, Handling and Disposal Practices

<u>Waste Hydraulic Fluids</u>

Waste hydraulic fluids and oils are generated by a number of operations, including machine shop operations, vehicle engine repair operations and replacement of aircraft hydraulic fluids. In addition, various hydraulic fluids are used in presses and in positioning and braking devices. Eventually, these fluids degrade and must be replaced. Such fluids are routinely drained from aircraft (for maintenance) or accidently spilled.

Currently hydraulic fluids and waste oils are collected in color coded drums, transferred to Naval Base, Norfolk, and processed for recycle or reclamation (Roberts et al., 1988).

<u>Solvents</u>

Solvents are employed to clean aircraft parts and metal surfaces, and to calibrate equipment. The types of solvents used by NAS Oceana are: hydrocarbons, halogenated hydrocarbons, oxygenated hydrocarbons, and mixtures thereof. Hydrocarbon solvents are typically light petroleum distillates (kerosenes) and are used as

cleaners, paint thinners, and vapor degreasers. Halogenated hydrocarbons are usually low molecular weight chloralkanes and are used for cleaning and vapor degreasing. Oxygenated hydrocarbons are mostly low molecular weight ketones and alcohols and are used for cleaning and paint thinning.

There are three types of solvent cleaning and degreasing operations common at NAS Oceana. These can be classified as: (1) cold cleaning, (2) vapor degreasing, and (3) metal preparations and precision cleaning.

Cold cleaning is the most common type of solvent cleaning. The solvent is applied either by brush or by dipping the item to be cleaned in a solvent dip tank. Ninety percent of the solvent used for this purpose is PD-680, a naphtha or Stoddard solvent. It is also known under other commercial names, such as Varsol (Higgins, 1989).

Vapor Degreasing is a method that uses high flash point, chlorinated hydrocarbons in the vapor phase to clean metallic and other tolerant material surfaces (Higgins, 1989). The solvent is situated in the lower portion ("pot") of a special tank where it is heated to boiling to fill the upper portions of the tank with solvent vapor. The item to be cleaned is inserted into the vapor region of the tank (either manually or by conveyor). The hot solvent vapor condenses onto the surface of the item and drips back (refluxes) into the liquid bath, carrying with it any dissolved dirt or grease. The solvent vapor is prevented from escaping into the atmosphere by use of a refrigerated condenser section arranged in the vent path constituting the upper condenser section in the upper part of the tank. The condensed solvent returns to the liquid sump or "pot" for reboil in the continuous reflux process. The solvents used in the vapor degreasing are trichloroethylene, perchloroethylene, 1,1,1-trichloroethane, and methylene chloride (Higgins, 1989). The low boiling point of this solvent (189° F) allows the use of low pressure steam for heating and permits handling of the cleaned parts almost immediately after cleaning. The next most popular solvent for vapor degreasing is 1,1,1-trichloroethylene. Its boiling point (165° F) is even lower than that of trichloroethylene. However, 1,1,1-trichloroethane is reactive with zinc and aluminum and cannot be used to clean those machinery or parts containing these metals.

The third major use of solvents at NAS Oceana is for metal preparation and precision cleaning. For metal preparation operations, the surfaces of a workpiece are cleaned prior to application of final surface coatings. Solvent such as alcohols, ketones, aliphatic esters, or cresylic acid are frequently used. The solvent employed in this application is usually lost to the air or absorbed in the wipe cloths or, if collected, is contaminated beyond specification allowances in the process. Solvents having

high purity, high solvency, and rapid evaporation rates (such as chlorofluorocarbons compounds) are used for the cleaning of precision instruments and electronic components. Solvents used for cold or hot carbon removal are mixtures, which may or may not include halogenated materials that are used to remove soot deposits from aircraft and engine parts.

Currently NAS Oceana tenants dispose of most of their solvent wastes by placing them in color coded drums and sending them to DRMO via PWD (Roberts et al., 1988).

Paints

Painting occurs at virtually all NAS Oceana tenant commands. The paint coatings used by the NAS Oceana shops include epoxies, enamels, lacquers, dry powders, and when permitted, paints containing antifouling agents, such as organotins. These coatings are applied to the surfaces of parts, vehicles, weapons, aircraft, and structures for surface and corrosion protection, identification, camouflage, and aesthetic appeal. Waste generated from painting operations include paint sludge (from overspray), solvents (aircraft maintenance equipment cleaning), and paints with an expired shelf life (Roberts et al., 1988).

Waste thinners are generated primarily through the cleaning of painting equipment. The type of solvent used varies with the coating (paint) and sometimes with the surfaces to be painted. Common solvents are methylethyl ketone (MEK), xylene, toluene, petroleum naphtha and mineral spirits. These are listed as RCRA hazardous waste because of their flammability and/or toxicity. Some names for naphtha are PD 680, VM&P Naphtha, and Lacquer Thinner. All are hydrocarbons that are flammable with a low flash point of 100° F and can cause sever eye irritation, headaches, dizziness, nausea and narcosis.

Generally, oxygenated hydrocarbon solvents, such as MEK, are used for epoxy and polyvinylchloride (PVC) coatings; aromatics, such as toluene and xylene, for chlorinated rubber, phenolic, and oil-based coatings. Thinner formulations rarely consist of a single chemical or petroleum distillate cut. They are usually carefully formulated mixtures designed to provide a specific thickness, coverage, and drying time. Generally the formula for paint thinner is 98% paraffins (including naphthenes), 2% aromatics with less than 0.1% benzene. The boiling range is from 313° to 404° F. It has a petroleum odor and the threshold limit in air is 125 pm.

Waste generated from powder-coating operations consist only of cleanup solvents. There is no other waste or expired paint for disposal. Powder overspray is collected in conventional air filter systems and can be reused. Typically, used solvents and paint are mixed and disposed of through DRMO (Roberts et al., 1988).

Battery Acid Sludges

Two types of sludge can result from battery repair and replacement operations. A lead sulfide sludge is generated in the battery during its lifetime. A second sludge is generated by pretreatment of the spent battery acids. Both of these sludges are collected by PWD and disposed of by DRMO. This operation requires the disposition of a waste that, at present, cannot be minimized through process modification or material substitutions. Neutralization of acids has been performed at other Naval Bases. There is ongoing research in new battery materials, which could result in the development of hazardous wastes presently encountered with battery disposal (Roberts et al., 1988).

III. TECHNOLOGY AND ALTERNATIVES

This section describes the treatment/recycle technologies that are or can be applied to the wastes generated by NAS Oceana.

A. Waste Hydraulic Fluid

The U.S. EPA is sponsoring research, development, testing, and evaluation (RDT&E) at Auburn University for the demetalization of waste oils. This research is particularly aimed at the waste lubricating oils that can be used as co-fired fuels in boilers without causing fireside fouling or corrosion. This is a pilot scale demonstration, wherein a dehydration/demetalization process previously developed at Auburn University is also being evaluated (Roberts et al., 1988).

B. Solvents.

Waste solvents can be reduced by converting to dry powder coating where appropriate, and converting to water-based/reducible coatings, where the mission is not compromised. Research & process development necessary to determine suitable powdered coatings without compromising coating function are conducted before implementation.

Treatment modifications are already underway at many Navy bases through the implementation of the Used Solvent Elimination Program. This program actively enforces the recycle and reclamation of waste solvents. Used solvents are processed through DRMO. The only waste that may require disposal or further treatment are sludges produced from solvent recovery stills.

C. Paint and related materials.

The largest contributing factor to the generation of painting wastes comes from "off-spec" material, expired shelf life material, and left over paint from large volume cans used for small jobs. This waste can be eliminated through the following management practices:

1. Consideration should be given to the concept of having original manufacturers rework expired shelf-life material. This would permit parties most knowledgeable in and best equipped for reconditioning assumedly deteriorated materials to recycle such items at specification grade with least cost to NAS Oceana. This approach would be appropriate only after it has been determined by adequate inspection by Navy personnel that the material should be reprocessed and that the shelf life for the material is realistically set.

2. The supply system should incorporate a Servmart [2] type of distribution arrangement for hazardous and potentially hazardous materials. NAS Oceana users could then purchase small quantities of needed items and not be constrained by the current, excessively high minimum limits that induce the wasteful practices ("store the balance and forget") that are sometimes encountered.

3. Similarly, shelf life terms specified for Navy materials should be reviewed to verify the technical validity of such (often obituary) assignments. A centralized laboratory equipped to perform material analyses and use-tests could be established for this purpose. Materials to be considered for reassessment could be evaluated systematically, beginning with the more questionable and larger volume items and continuing until the mission is fulfilled (Roberts et al., 1988).

D. Battery fluid acid.

The assessment of waste sulfuric acid management at battery shops results in a strong recommendation of the current practice at the shops. This consists of neutralizing the acid in the shop area and sending the product to be treated at the Norfolk Naval Base industrial wastewater treatment plant (IWTP). The concept of using the acidic battery waste as a neutralizing chemical is not attractive, partly because of the volumes generated. The waste acid has been too diluted to be economical as an IWTP reagent. (Roberts et al., 1988).

E. Other Alternatives

A process that is often referred to as "bioremediation," is emerging as a powerful treatment technology for biological degradation of hazardous waste from ongoing operations to inactive disposal sites. Organisms that can be used for biotechnology include aerobic and anaerobic bacteria and less often, fungi and yeast. Laboratory, pilot, and full scale studies have successfully demonstrated the use of biotechnology for degradation of petroleum hydrocarbons, phenols, cyanide compounds, trichloroethylene, and polychlorinated biphenlys (Hausknecht, 1989).

---

[2] Service Market (SERVMART) is the self-service division of the Supply Department where Military organizations procure small amounts of routine supplies such as office and cleaning items, paint, tools, etc. It is similar in operation to a civilian department store but purchase orders are used to transfer funds in lieu of cash. This format allows the Navy to take advantage of discount volume purchasing and provide small amounts to the users.

Filtration/Dewatering

Off-site lubricating oil recyclers use settling tanks to separate free water from used oil. These tanks can range in volume from 1,000 to 10,000 gallons or more and can be operated at ambient temperatures or at elevated temperatures (100°F) to facilitate the breaking of emulsions. Some recyclers use chemical demulsifiers to assist in separating free water. The oil is usually strained (filtered) prior to dewatering and again after the dewatering step. This technology is applicable to the manufacture of burner fuel supplement from used lubricating oil. The product must meet the regulations established by EPA for burning which includes halogen and heavy metal content.

Diesel Fuel Supplement

With absolute control of waste oil segregation from contaminants such as solvent, antifreeze, hydraulic fluids, and water, a relatively simple commercially available device can be used to strain and filter debris and larger particulate (>2 microns) from the used oil, remove free water by means of an integrated oil/water separator and blend the cleansed crankcase drainings with diesel fuel at a ratio of 1 part oil to 50 parts fuel. Such a dilution ratio assures that any regulated contaminants such as lead (from tetraethyllead) and halogens (from additives) will remain well below hazardous levels. This application has been used for many years by a number of commercial trucking firms (NEESA, 1989).

Re-refining

Re-refining utilizes a number of technologies including dewatering, filtration, flash distillation, thin-film evaporation and/or fraction distillation and hydrogenation. Only a few re-refiners still operate in the United States because the process is so complex and cost-effectiveness is minimal (NEESA, 1989).

While fraction distillation of used oil is seldom the primary process in commercial re-refining of used lubricating oil, it can be used in series with thin-film technology to produce fractions representing differing grades of motor oil. The equipment is costly ($30,000 +), complex and not suitable for general Naval application to recycling of used oil (NEESA, 1989).

A distillation apparatus frequently used by commercial re-refiners to restore used oil to original base stock quality is thin-film or wiped-film evaporator distillation. These units are generally used in current re-refining technology as one of the steps in the cleansing of lubricating oil. The apparatus consists of a heated surface which is wiped by a rotating mechanism to expose a thin

film of the feed to the elevated temperature required to vaporize desired components. Ordinarily, the oil is first treated to remove water and lower boiling materials (<290° C/550° F) before the thin-film step which takes the lubricating oil overhead and leaves the sludge, particulate, and debris behind as a residue. These units are very versatile and specially suited for viscous liquids. However, they would generally be too complex for most Navy applications. Costs range from about $30,000 and up.

IV. COST ANALYSIS

The disposal options discussed in Section V are considered to be the potential alternatives to the current practices at NAS Oceana. This section provides cost calculations for these recommended options. The cost of current practices is presented in Table 4.1. These costs are based on the disposal of items handled through the DRMO contract, including the charge by PWD for packaging and handling. The cost of transportation and labor is not included in these figures. The cost for the stills are estimates from the manufacturer: Finish Company, Inc.

Table 4.1

SUMMARY OF COST OF CURRENT DISPOSAL

Waste	Volume (gal/yr)		Costs ($)		Costs ($/gal)
Solvent (PD-680)	2200		5025		2.28
Paint thinners	2000		3520		1.76
Freon	2365	2600	7095	8983	3.00
& TCA	236		1888		8.00

Table 4.2

SUMMARY OF COST OF RECOMMENDATIONS

Waste	Volume (gal/yr)		Costs ($/gal)
Solvent (PD-680)	2200		1.92
Paint thinners	2000		0.48
Freon	2365	2600	0.89
& TCA	236		

COST FIGURES FOR STILL #1, for PD 680

Still Site: Public Works Department Model: LS-55IID (Finish Co.)

Total value recycled = 80% recovered x volume generated (gal/year) x value ($/gal)
= 0.8 x 2200 (gal/year) x $2.45/gal
= 4312 $/yr

Disposal savings = Volume generated (gal/year) x disposal cost ($/gal)
= 2200 (gal/year) x $4.23/gal
= 9306 $/yr

Cost of solvent replacement = 20% solvent loss x volume generated (gal/year) x value ($/gal)
= 0.2 x 2200 (gal/year) x $2.45/gal
= 1078 $/yr

Recycling cost = total recurring cost/volume generated (gal)

Recurring cost

Cost item	($)
Maintenance (2% of capital cost)	460
Utilities (2% of capital cost)	460
Manpower (0.5 hr/batch x $8.00/hr x 2200 gal/year x batches/55 gal)	160
Transportation ($0.20/gal x 2200 gal/year	440
Sludge fuel credit (20% sludge x 2200 gal/year x $0.60/gal)	(264)
Analysis ($.30/gal x 2200 gal/year	660
Depreciation (10% of capital)	2300
Total Recurring Costs	4216

Cost per gallon distilled: $1.92

Capital cost

Equipment	($)
Solvent still LS-55IIDV	20,000
Installation	1,000
Contingency (10% of equipment)	2,000
Total	23,000

$$\text{Payback period} = \frac{\text{Capital cost}}{\text{Total value recycled + disposal cost savings - (cost of replacement + recycle cost)}}$$

$$= \frac{23{,}000}{(4{,}312 + 9{,}306) - (1{,}078 + 4{,}216)}$$

$$= 23{,}000/8{,}324 = 2.7 \text{ years} = 33 \text{ months}$$

Managements credits = \$8,324

COST FIGURES FOR STILL #2, for paint thinners

Still site: Public Works Department

Model: LS-55IID (Finish Co.)

Total value recycled = 80% recovered x volume generated (gal/year) x value ($/gal)
= 0.8 x 2,000 (gal/year) x $5.50/gal
= 8,800 $/yr

Disposal savings = Volume generated (gal/year) x disposal cost ($/gal)
= 2,000 (gal/year) x $7.00/gal
= 14,000 $/yr

Cost of solvent replacement = 20% solvent loss x volume generated (gal/year) x value ($/gal)
= 0.2 x 2,000 (gal/year) x $5.50/gal
= 2,200 $/yr

Recycling cost = Total recurring cost/volume generated (gal)

Recurring cost

Cost item	($)
Maintenance (2% of capital cost)	460
Utilities (2% of capital cost)	460
Manpower (0.5 hr/batch x $8.00/hr x 2000 gal/year x batches/55 gal)	145
Transportation ($0.20/gal x 2000 gal/year	400
Sludge fuel <u>credit</u> (20% sludge x 2000 gal/year x $7.00/gal)	(2800)
Analysis no analysis us required	-0-
Depreciation (10% of capital)	2300
Total Recurring Costs	965

Cost per gallon distilled: $0.48

Capital cost

Equipment	($)
Solvent still LS-55IID	20,000
Installation	1,000
Contingency (10% of equipment)	2,000
Total	23,000

$$\text{Payback period} = \frac{\text{Capital cost}}{\text{Total value recycled + disposal cost savings - (cost of replacement + recycle cost)}}$$

$$= \frac{23{,}000}{(8{,}800 + 14{,}000) - (2{,}200 + 965)}$$

$$= 23{,}000/19{,}635 = 1.17 \text{ years} = 14 \text{ months}$$

Managements credits = $19,635

COST FIGURES FOR STILL #3, for Freon & TCA

Still Site: Aircraft Intermediate Maintenance Division
Model: LS-15IID (Finish Co.)

Total value recycled = 80% recovered x volume generated (gal/year) x value ($/gal)
= 0.8 x 2,600 (gal/year) x $5.50/gal
= 11,440 $/yr

Disposal savings = Volume generated (gal/year) x disposal cost ($/gal)
= 2,600 (gal/year) x $7.00/gal
= 18,200 $/yr

Cost of solvent replacement = 20% solvent loss x volume generated (gal/year) x value ($/gal)
FREON = 0.2 x 2,365 (gal/year) x $10.89/gal
= 5,151 $/yr

1,1,1 TCA = 0.2 x 236 (gal/year) x $5.07/gal
= 239 $/yr

Recycling cost = Total recurring cost/volume generated (gal)

Recurring cost

Cost item	($)
Maintenance (2% of capital cost)	230
Utilities (2% of capital cost)	230
Manpower (0.5 hr/batch x $8.00/hr x 2600 gal/year x batches/55 gal)	189
Transportation ($0.20/gal x 2600 gal/year	520
Sludge fuel credit (20% sludge x 2600 gal/year x $7.00/gal)	(3640)
Analysis [2365 gal ($0.90/gal + 236 ($1.00/gal)]	2365
Depreciation (10% of capital)	1150
Total Recurring Costs	2319

Cost per gallon distilled: $0.89

Capital cost

Equipment	($)
Solvent Still Model LS-15IID	10,000
Installation	500
Contingency (10% of equipment)	1,000
Total	11,500

Freon = ($0.40 initial distillation + $0.20 boiling point + $0.20 residue + $0.10 particle count)/gal = $0.90/gal

1,1,1 TCA = ($0.40 initial distillation + 0.40 distillation + 0.20 residue)/gal
= $1.00/gal

$$\text{Payback period} = \frac{\text{Capital cost}}{\text{Total value recycled + disposal savings} - (\text{cost of replacement + recycle cost})}$$

$$= \frac{11{,}500}{(11{,}440 + 18{,}200) - (5{,}390 + 2{,}319)}$$

= 11,500/21,931 = 0.52 years = 6.3 months

Managements credits = $21,931

V. Recommendations

A. Hydraulic fluids

Routine "Patch" [3] testing, which is performed to determine the condition of hydraulic fluids in jet aircraft, results in a mixture of synthetic hydraulic fluid and freon that can be recycled. This mixture is a hazardous waste, but its volume can be reduced by on-site recycling to separate the synthetic hydraulic fluid and freon. The separated hydraulic fluid can then be disposed of via DRMO without penalty for being hazardous waste while the Freon can be recycled on-site to original use.

One on-site technology to separate synthetic hydraulic fluid and Freon 113 is steam distillation. To make the option cost effective, it is necessary to perform secondary distillation on the Freon to separate it from water produced by condensate steam.

Distillation columns or evaporators take advantage of the differences in volatility of impurities and the material to be purified. A distillation column and evaporator (still #3 in section IV) is recommended to remove solvent contamination from synthetic hydraulic fluids (NEESA, 1989). Finish Company, INC is one manufacturer that makes many models of stills that are suitable, see Appendix C.

B. Solvents

NAPHTHA

The technology available for on site recycling of naphtha is a single-stage batch distillation. If the annual generation exceeds 1,000 gallons, a fully automated, 15 gallon per shift distillation unit with stainless steel, water-cooled condenser is the technology of choice. If the annual volume generated is less than 1,000 gallons, a 3-5 gallon single-stage batch distillation unit with a water-cooled condenser is adequate for recycling naphtha on-site.

---

[3] To obtain optimum performance and reliability in aircraft hydraulic systems, hydraulic fluids must be maintained within acceptable contamination levels. Sampling/testing of hydraulic fluid is accomplished on a regular basis. This testing is called a "patch" test, because the sample mixed with freon is passed through a filter that resembles an eye patch. The patch is compared to published acceptable standards. When the hydraulic fluid sample fails to meet required standards, decontamination procedures are employed in accordance with Navy instructions.

Since the volume of aliphatic naphtha is combined with a larger volume of other recyclable solvents (of similar value) these solvents can use the same technology and equipment. Therefore, a larger on-site recycling equipment, still #1 (sect IV), a 55 gallon unit, is recommended.

Major contaminants in aliphatic naphtha are dirt, grease, fuel, lacquer, oils, paints and varnish. It is recommended that aliphatic naphtha be carefully segregated from the other oils and solvents to prevent creation of large quantities of hazardous waste. Aliphatic naphtha can be combined with other non halogenated low-flash used solvents and oils for DRMO recycling/disposal. If contamination with halogens is a possibility, the testing should be performed as defined in the Code of Federal Regulations (NEESA, 1989).

1,1,1-TRICHLOROETHANE (TCA)

1,1,1-Trichloroethane is called methyl chloroform, trichloroethane, Trichlor and Chlorothene. The vapors are toxic and the threshold limit in air is 350 ppm. Poisonous gases are produced when 1,1,1-trichloroethane is heated. It boils at 165° F and is volatile but is not flammable.

The technology required for on-site recycling of 1,1,1-trichloroethane is distillation. A single-stage, atmospheric, batch feed distillation unit with a stainless steel water-cooled condenser capable of processing 3-5 gallons per shift is recommended. Both TCA and Freon can be distilled in still #3.

Major contaminates in 1,1,1-trichloroethane are dirt, grease, lacquer, oils, paints, resins and metals. 1,1,1-trichloroethane should be carefully segregated from the other oils and solvents and avoid further contamination by consistent good-housekeeping practices. 1,1,1-trichloroethane is a halogenated compound and mixing or blending with any other used oil and solvent multiplies the total volume of hazardous waste.

Storage of used 1,1,1-trichloroethane is necessary during the interim required to accumulate a sufficient volume for recycling or disposal. Storage should be achieved in clean 55-gallon labeled drums. Underground tank storage is not recommended. (NEESA, 1989)

C. Waste Paint and Related Materials

Paint Strippers

This is a mixture of halogenated, phenolic (oxygenated), and chromate (oxidizing agent). The formula is greater than 50% methylene chloride, less than 25% phenol, and 1% sodium chromate (Na_2CrO_4). This is a highly corrosive liquid and the sodium chromate is a recognized carcinogen.

There is no established procedure, equipment or technology for on-site recycling of paint removers. Closed loop recycling is not a viable option for paint remover recycling. Therefore off-site recycling or DRMO disposal is recommended.

Major contaminants in used paint removers are carbon, dirt, grease, oils, lacquer and paint. Its primary use in the Navy is to remove epoxy from aircraft surfaces and as a carbon remover. Therefore it is recommended that it be carefully segregated from other oils and solvents and avoid further contamination. a log should be maintained which includes a listing of waste drums, dates of deposits, identification of activity and personnel making the deposit and description of the quality and quantity and identification of the material deposited in the drum (NEESA, 1989).

Paint thinners

The technology recommended for on-site recycling of paint thinner is a single-stage batch distillation. Since the annual generation exceeds 1,000 gallons, still #2 (section IV), a fully automated, 15 gallon per shift, distillation unit with stainless steel, water-cooled condenser is the technology of choice (NEESA, 1989).

D. BATTERY ELECTROLYTE

This material is concentrated sulfuric acid that has been diluted with rinse water and contaminated with lead. The corrosiveness of the fluid renders it hazardous. If the lead content is greater than 5 mg/l, spent electrolyte would be considered hazardous also because of its contamination with toxic heavy metal.

Neutralization alone is acceptable treatment for these wastes, if the concentration of lead in the spent electrolyte is less than 5 mg/l. However, neutralization (typically with lime) does not completely remove the lead, which is usually present at greater levels. Therefore most of the effluent from neutralization should go to the Norfolk Naval Base industrial wastewater treatment plant.

Removal of lead prior to mixing neutralized battery shop wastewater with other waste streams at an industrial wastewater treatment is

important. The pretreatment options for reducing lead levels include chemical precipitation and electrolyte recovery.

Chemical precipitation - When greater than 5 mg/l, lead can be precipitated at elevated pH with lime, sodium hydroxide, sulfides, carbonates, or phosphates. Lead removal occurs at many battery shop neutralization pits when lime is used as the alkali. The residual, dewatered sludge should be sent to a reclaimer.

Electrolyte recovery - The lead in the liquid should be plated out on the cathode of an electrochemical cell. The remaining acid is then suitable for reuse as a waste treatment chemical (Roberts et al., 1988).

It is recommended that NAS Oceana's operating battery shops that do not have neutralization capability, install such equipment.

VI. SUMMARY

1. Hydraulic fluids - remove contamination by distillation

2. Solvents - utilize on-site recycling equipment

3. Waste Paints and related material - DRMO disposal or off-sie recycling

4. Battery eletrolyte - neutralize and forward to Norfolk Naval Base IWTP

VII. REFERENCES

1. Used Oil and Solvent Recycling Management Program, NAS Oceana, VA, July 1989, NEESA 19.1-034

2. NAS Oceana CY89 Hazardous waste Annual Report, 13 February 1990

3. Hazardous Waste Minimization Initiation Decision Report, R.M. Roberts, J.L. Koff and L.A. Karr, June 1988, Tn-1787

4. S.L. Collignon and D.R. Knudsen, Recovery of Mineral Spirits Contamination, Naval Surface Weapons Center Report TR86-65, October 1985

5. T.E. Higgins, Industrial Processes to Reduce Generation Of Hazardous Waste, CH2M Hill Report, February 1985

6. Used Oil and Solvent Recycling Technology Transfer Manual, August 1989, NEESA 19-001A

7. B. Hausknecht, Energy & Environmental News, NEESA, August 1989

8. Federal Register, VOL 49, NO 134, 1984

9. J. P. Martin, Shi-Chieh Cheng, and M. A. Susavidge, Hazardous and Industrial Wastes, Technomic Publishing, 1990

10. J. F. Mariorano and G. Annamraju, "Hazardous Waste Minimization in Air Force Logistics Command," The Military Engineer, August 1990, pg 16

11. T. E. Higgins, Hazardous Waste Minimization Handbook, Lewis Publishers, 1989

12. H. M. Freeman, Innovative Hazardous Waste Treatment Technology Series, Technomic Publishing, 1990

APPENDIX A: Acronyms

AIMD	Aircraft Intermediate Maintenance Division
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CFR	Code of Federal Regulations
DOD	Department of Defense
DOT	Department of Transportation
DRMO	Defense Reutilization and Marketing Office
EP	Extraction Procedure
EPA	U. S. Environmental Protection Act
FITWING	Fighter Wing
GSE	Ground Support Equipment
HMC&M	Hazardous Material Control and Management
HSWA	Hazardous and Solid Waste Amendments
MATWING	Medium Attack Wing
MEK	Methylethyl Ketone
MI	Maintenance Instruction
MIBK	Methylisobutyl Ketone
MILSPEC	Military Specification
NAS	Naval Air Station
NEESA	Naval Energy and Environmental Support Activity
NEX	Navy Exchange
OPNAVINST	Operational Naval Instruction
OSHA	Occupational Safety and Health Act

ppm	Parts per Million
PWC	Public Works Center
PWD	Public Works Department
RCRA	Resource Conservation and Recovery Act
SARA	Superfund Amendment and Reauthorization Act
TCA	1-1-1 Trichloroethane

APPENDIX B: Glossary of terms

Alcohols - Colorless, volatile, pungent liquids consisting of alkanes (saturated hydrocarbons) or aromas (cyclic or ring compounds) containing one or more hydroxyl (-OH) groups.

Chlorinated hydrocarbons - A hydrocarbon (compound consisting of carbon and hydrogen) in which one or more of the hydrogen atoms have been replaced with chlorine atoms.

Chlorofluorocarbons (CFC's) - A hydrocarbon (compound consisting of hydrogen and carbon) in which the hydrogen atoms have been replaced with chlorine and fluorine atoms.

Closed-loop recycling - A procedure by which used oils or solvents are recycled and regenerated to new-product quality, and made available for further use.

Coalesce - Coalescence is a technique for oil/water separation. Oil droplets are caused to grow together, coalesce, into larger drops so that they either float or settle. Coalescing separators operate by providing a surface that attracts oil but repels water.

Downgrading - The designation of a product to a role which is not the original use for which the material was intended. As implied, downgrading means using a material for a purpose which is technically and/or economically less attractive than the primary role. An example is the use of used lubricating oil as a burner fuel supplement.

Flash point - The lowest temperature at which application of a flame or spark causes the vapors above the surface of a liquid to ignite is called the flash point.

Generator - Any person, by site, whose act or process produces hazardous waste listed in Part 261 of 40 CFR, Subpart D, Chapter 1.

Hazardous waste - A hazardous waste as defined in 40 CFR, part 261.

Halogens - An organic compound containing one or more of the halogens--chlorine, fluorine, bromine, and iodine.

Hi-flash materials - Materials with a flash point of 140° F or higher designated as high-flash materials.

Ketones - A ketone is a hydrocarbon containing a carbonyl group. The carbonyl group is a carbon atom and an oxygen atom linked together by a double (unsaturated) bond. The general structure formula for a ketone is RCOR' where R and R are alkyl (carbon and hydrogen) groups. It is completely miscible with water and such products as gasoline so that it is a good solvent.

Manifest - The shipping document EPA form 8700-22 and if necessary,

EPA form 8700-22A originated and signed by the generator.

Off-site recycling - This recycling option involves taking used oil os solvents from a Navy activity, mixing it with similar materials from other sources, cleansing the whole and returning an aliquot of the whole to the Navy.

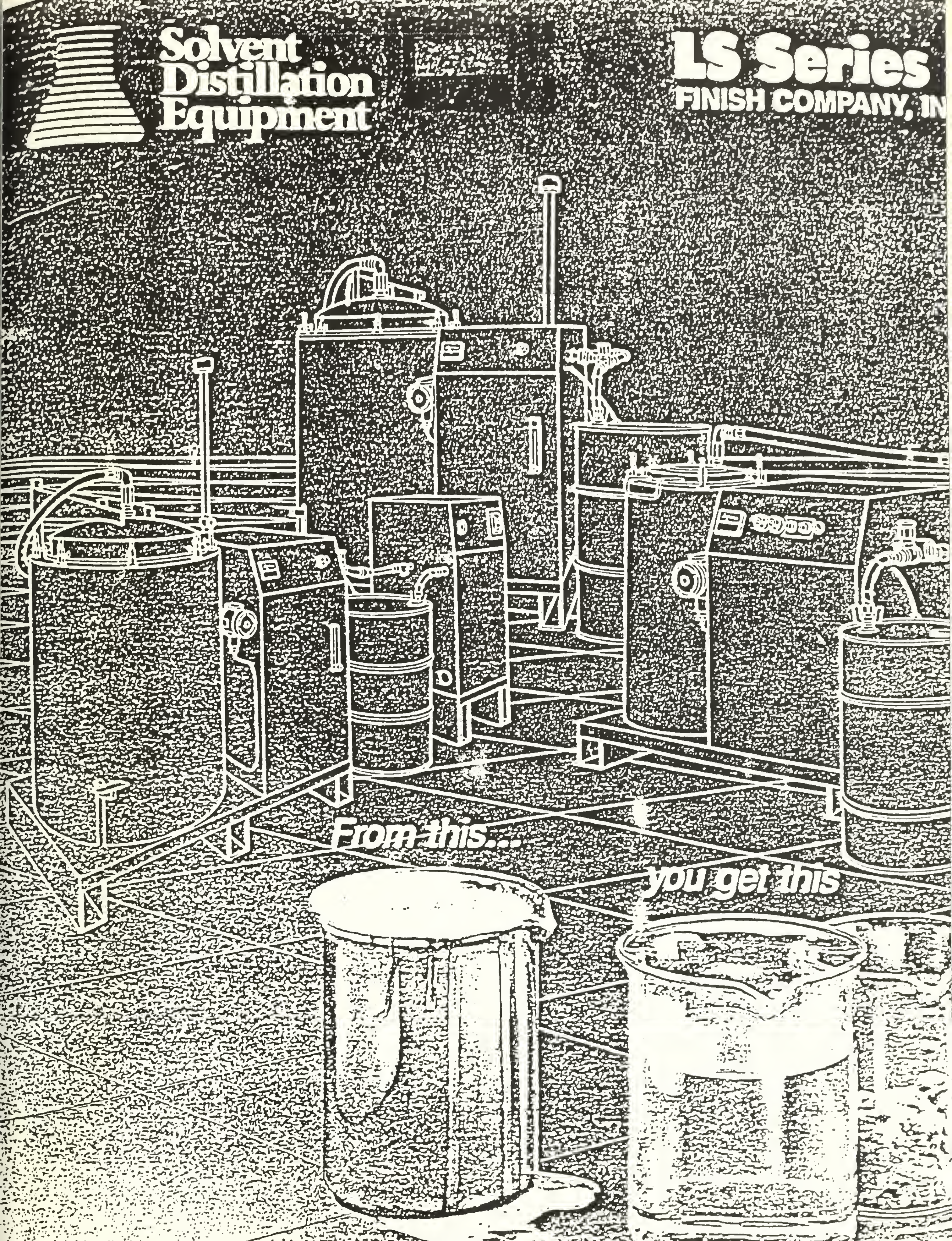
Reclaiming - Recycling, restoring a used oil to a quality suitable for a useful role such as burning for energy recovery.

Segregation - The process of collecting and grouping used oils and solvents to avoid incompatible mixtures, contamination, and enhance recycling.

Used solvents - All used organic fluid contaminated as a result of use for cleaning, thinning, or use as a solvent, antifreeze or similar purpose. Used solvents are generally volatile in nature. They include hydrocarbons, halogenated hydrocarbons, oxygenated hydrocarbons, mixtures and other types of materials.

Waste oil - Includes all used petroleum/synthetic-based products whose characteristics have changed so markedly since being originally manufactured that they have become unsuitable for recycling.

APPENDIX C: Manufacturer's Data


Solvent
Distillation
Equipment
LS Series
FINISH COMPANY, IN
From this...
you get this

In-House Solvent Recovery

Small Volume Batch Feed

Thousands of Installations

Turn your hazardous waste solvent into profits with Finish Company, Inc. in-house solvent recovery equipment. Manufacturing solvent handling equipment for over hirty years, Finish Company has established itself as the industry leader in n-house solvent distillation technology.

Thousands of distillation units operating successfully attest to the reliability of our equipment. Companies worldwide are reclaiming contaminated solvents on-site nto clean, reusable solvent for just pennies per gallon

Advantages

LS Series solvent recovery equipment is uniquely designed and can provide many ears of safe, simple and efficient daily operation . . . virtually maintenance-free. his equipment provides typical payback 6 to 12 months and when properly installed and operated satisfies the most ringent safety and emission standards or in-house solvent reclamation.

ompared to outside reclamation serces, in-house distillation with LS equipent can return a purer product, provide higher recovery yield and allow you to ontrol your distillation schedule — all at ceptionally low operating costs.

addition, liabilities for transportation and sposal of hazardous waste are subantially reduced. In recent years, the esource Conservation Recovery Act CRA) has given "cradle to grave" responsibility to generators of hazardous waste for its storage, transportation and disposal

In-house reclamation reduces the staggering cost of handling waste in compliance with EPA regulations

Capacities

The LS Series is comprised of four basic models designed to process batches of 3.5, 15, 55 or 110 gallons of contaminated solvent per shift. The standard units are capable of handling solvents with boiling points ranging from 100° to 320°F. For solvents with boiling points from 320° to 500°F, use our standard LS Series plus optional vacuum attachment.

Safety Design

Finish Company solvent recovery equipment is unmatched in its attention to daily operator safety and environmental responsibilities. All LS Series units strictly adhere to Class I, Division I, Group D (NEMA 7) electrical code standards. Each LS unit is accompanied by a Stilmanual, which provides careful recommendations on installation and operation

Made in the U.S.A.

LS equipment is researched, designed, produced and tested at our 50,000 square foot modern manufacturing facility located in Erie, Pennsylvania.

Meeting Your Requirements

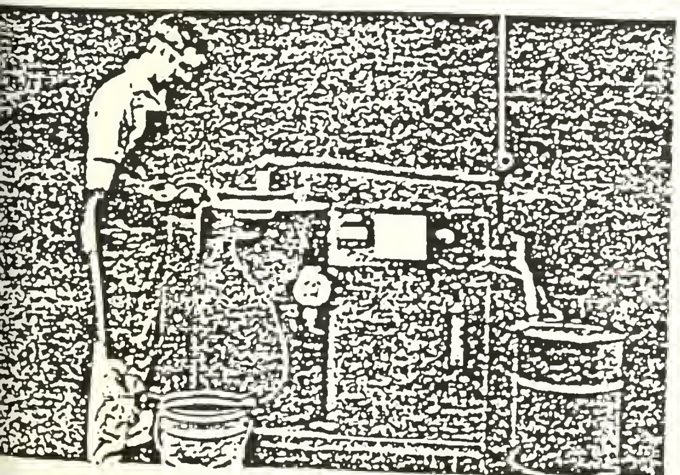
Prospective applications are evaluated by our Engineering and R & D Department to ensure that each unit meets specific usage requirements. In our fully staffed and equipped Laboratory we conduct daily evaluations concerning all facets of distillation technology

Contract testing is available. You send a clearly defined sample of your contaminated solvent to be distilled, and Finish Company will provide reports and an LS equipment recommendation. Demonstrations and full scale testing can be arranged on any of the LS Series units. Our field sales distributors will also visit your facility and provide recommended installation guidelines.

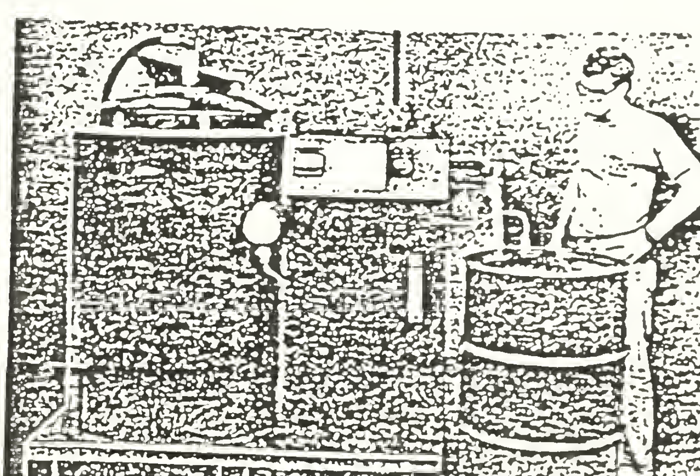
Consult Those Who Know

Finish Company sales engineers and chemists offer years of experience in solvent distillation covering diverse industrial applications and stringent military specifications. Printers, paint manufacturers and users, fiberglass molders, utility companies, government agencies and metalworking plants are just a few of those reclaiming millions of gallons of solvent on-site each year with Finish Company equipment.

A network of North American and International sales representatives offer continued support. These people have constant direct line access and contact with Finish Company, Inc.



...rial fabricator recovers 99% pure degreasing solvents with a Model ...SD. Investment payback was realized in just a few months. This is one ...ousands of successful installations in use worldwide by printers, fiberglass ...ders and manufacturers of paint, adhesives, electronics, auto parts, etc.



A midwest paint manufacturer uses a Model LS 55DV to distill 55 gallons per day of solvent contaminated with various paint pigments and resins. Solvents reclaimed include MEK, MIBK, xylene, methanol, toluene and cellosolve acetate. Payback was realized in a few short months.

How it Works . . .

Boiling Chamber Filled

Solvent is poured or pumped into the Teflon*-coated boiling chamber which the operator lines with a standard Stilbag. In lieu of Stilbag, an optional Teflon-coated Stilpan may be used.

Solvent Heated

After the chamber lid is secured, power to the unit is activated. Heat is transferred from the patented encapsulated heater through the conductive walls of the chamber directly into the solvent.

Vapors Formed

As the solvent boils, vapors form and pass through the vapor tube into a water-cooled shell-and-tube condenser.

Vapors Condensed

Vapors are condensed into a liquid state. This clean, clear, 99%-pure distillate gravity flows into an approved customer-provided 15- or 55-gallon drum.

Cycle Completed

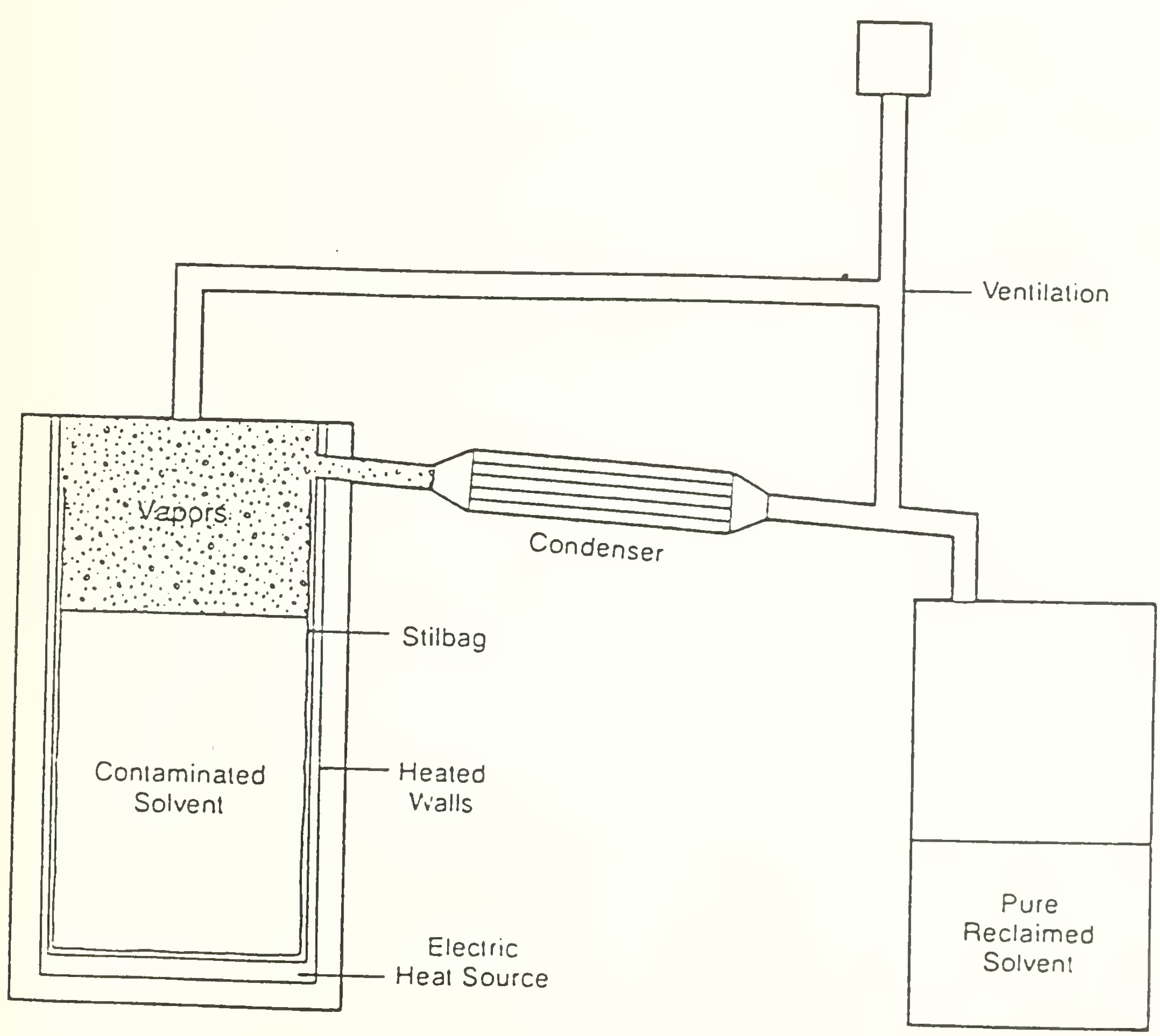
When visual check through sight glass indicates no further distillate is available the unit is shut off and allowed to cool.

Residue Removed

Residue remaining behind in the Teflon-coated boiling chamber is then removed with the Stilbag or optional Teflon-coated Stilpan.

*DuPont registered trademark

Distillation Schematic



Design and Safety Features

Safety Design

Finish Company solvent reclaimers are built to Class I, Division I, Group D (NEMA 7) standards of the National Electrical Code.

Patented Encapsulated Heating Element

Heating element is encapsulated within the vessel bottom insuring direct heat to 100% of the vessel surfaces. This method eliminates the need for inefficient hot oil immersion heating. The encapsulated heater on all LS Series units carry a five year warranty.

Residue Removal System

Residue is contained within disposable Stilbag liner for convenient removal and handling. Teflon-coated Stilpan is optionally available. Distillation chamber is Teflon coated for ease of cleaning.

Water-Cooled Condenser

Efficient shell-and-tube design provides complete condensing of vapors, allows easy cleaning, and eliminates need for pumps or other moving parts. Solvent gravity flows into an approved customer-provided 15- or 55-gallon drum.

Push/Pull Lighted Indicator

Shows on and off positions. Light indicates sufficient water flow through condenser for operation of boiling chamber

Condenser Water Flow Switch/Interlock

The distillation unit operates ONLY when sufficient volume of cooling water is present. Interruption of water terminates power to unit.

Adjustable Flow Meter

Console-mounted gauge with dial allows personnel to set volume and observe actual flow of cooling water to condenser for efficient usage.

Adjustable Temperature Controller

Operating temperature can be set to 350°F.

Vapor Temperature Gauge

Indicates vapor temperature throughout distillation run. Used to determine the optimum termination point.

Quick Cool Coil

Allows for fast cooling of distillation tank for multi-shift use.

Vacuum Capability

All LS Series units will accept our unique JetVac Attachment allowing recovery of solvents with boiling points up to 500°F.

Dual Thermostat Controls

Two override thermostat controls are provided so that the unit temperature does not exceed the Underwriters Laboratory's recommendation for heater temperature in a Class I, Division I, Group D environment.

Fully Insulated

Total distillation tank including lid is insulated with ceramic fiber for heat retention to provide efficient distillation.

Dual External Venting System (DEVS)

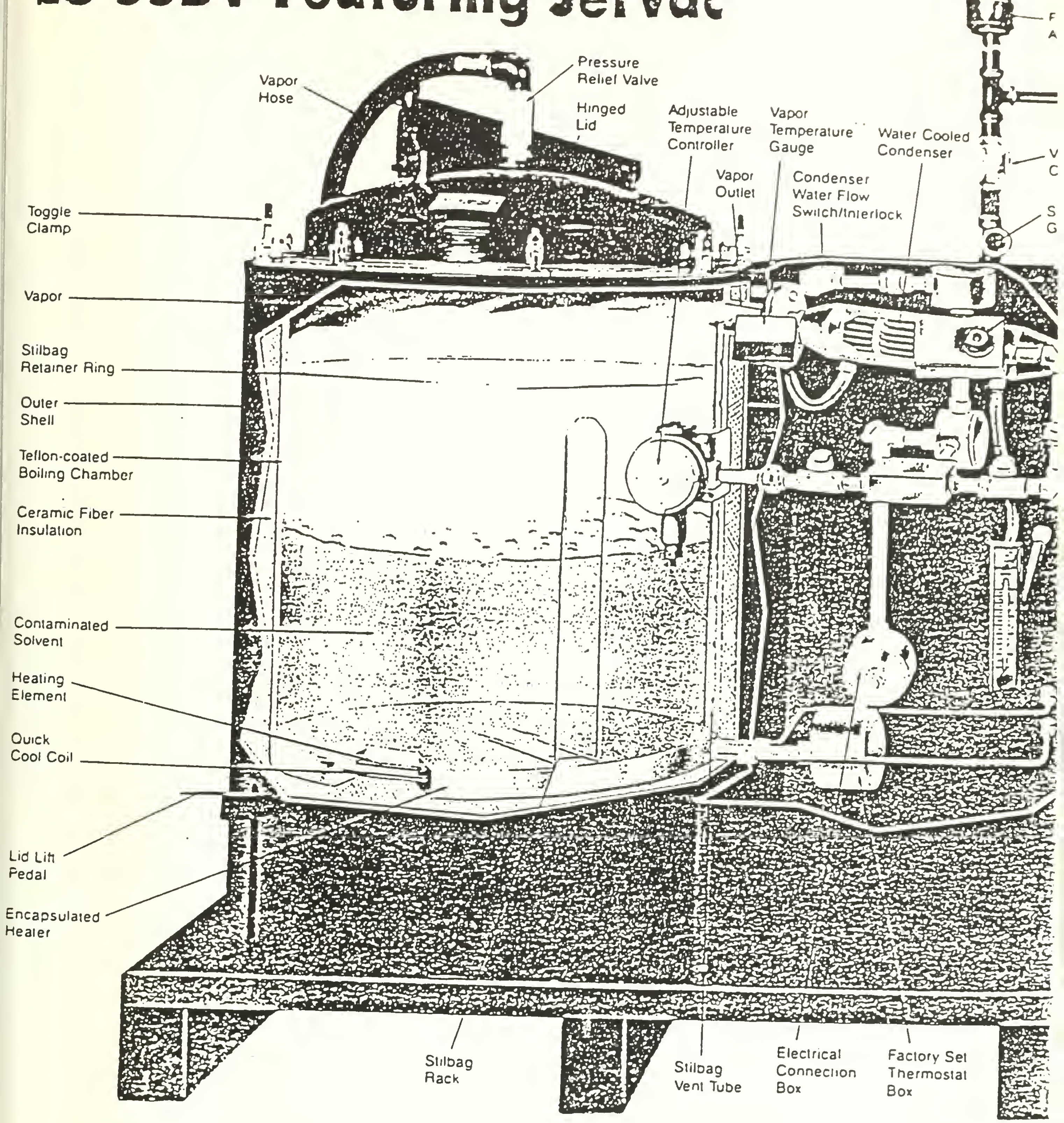
Provides safe transmission of potential vapors away from distillation site when properly customer-installed and operated. DEVS involves:

- Pressure Relief Valves
  - a) enables vapors to escape into DEVS from boiling chamber at .5 psi.
  - b) prevents pressurization of distillate receiving container.
- Vacuum Attachment Port for installation of modular vacuum attachments.
- Swing Check provides for vapor exhaust under vacuum operation.
- Sight Glasses allow visual inspection of
  - a) venting system
  - b) reclaimed distillate flow.
- Flame Arrester conforms to NFPA requirements for the emission of vapors

Installation Guidelines

- Still must be located in an enclosure with only explosionproof electrical devices present and with electrically interlocked floor ventilation.
- Ground all containers
- Still installation must be approved by an accredited inspector prior to operation
- Detailed manual and safety instructions accompany each still

LS-55DV Featuring JetVac



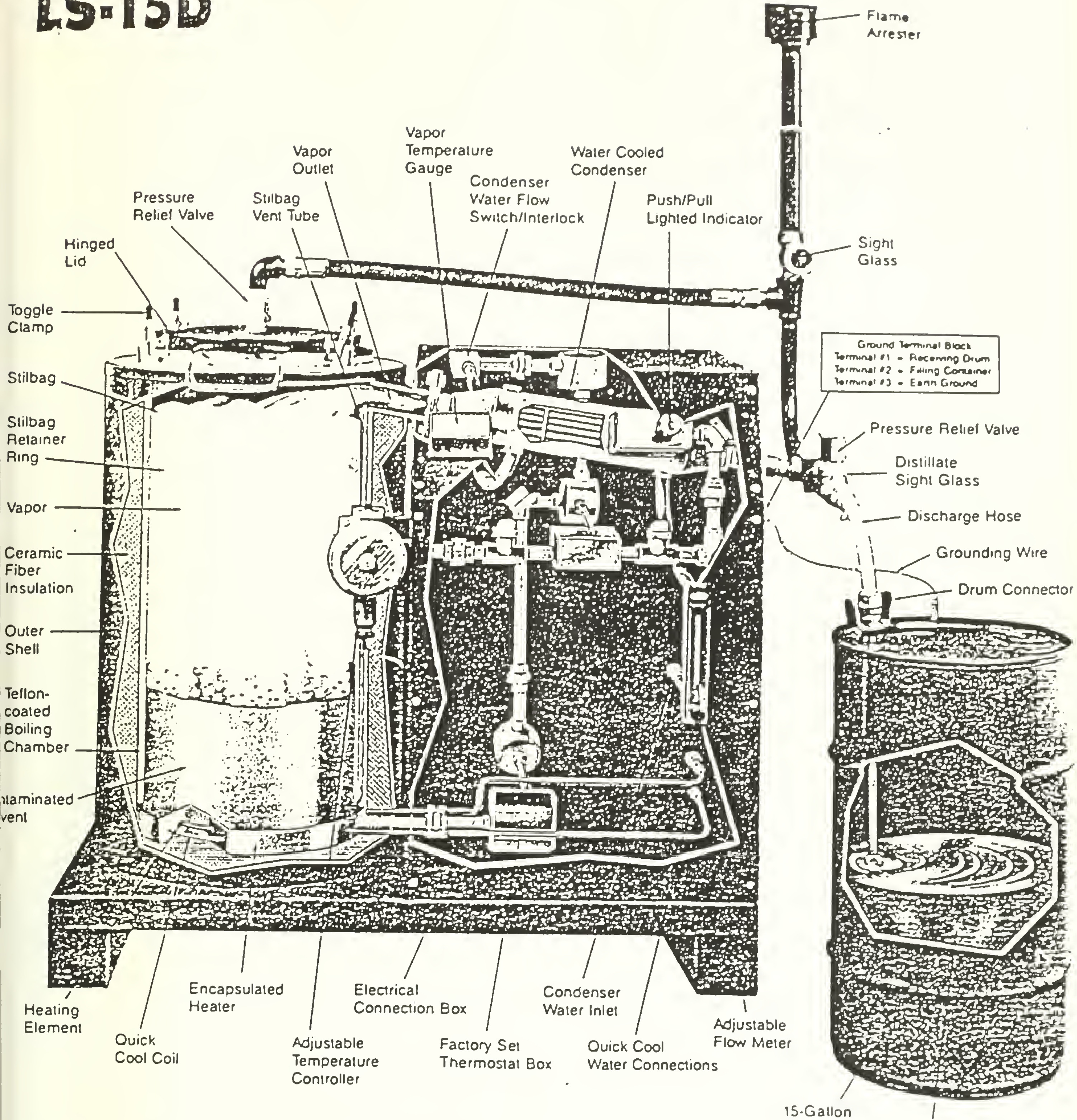
The Model LS-55DV processes up to ten 55-gallon drums of contaminated solvent per week at an average rate of 55 gallons per 6-8 hours. This unit features Finish Company's exclusive JetVac attachment allowing reclamation of solvents with boiling points up to 500°F. JetVac is optionally available and compatible with all LS Series designs and retrofitable for existing installations.

JetVac Operation

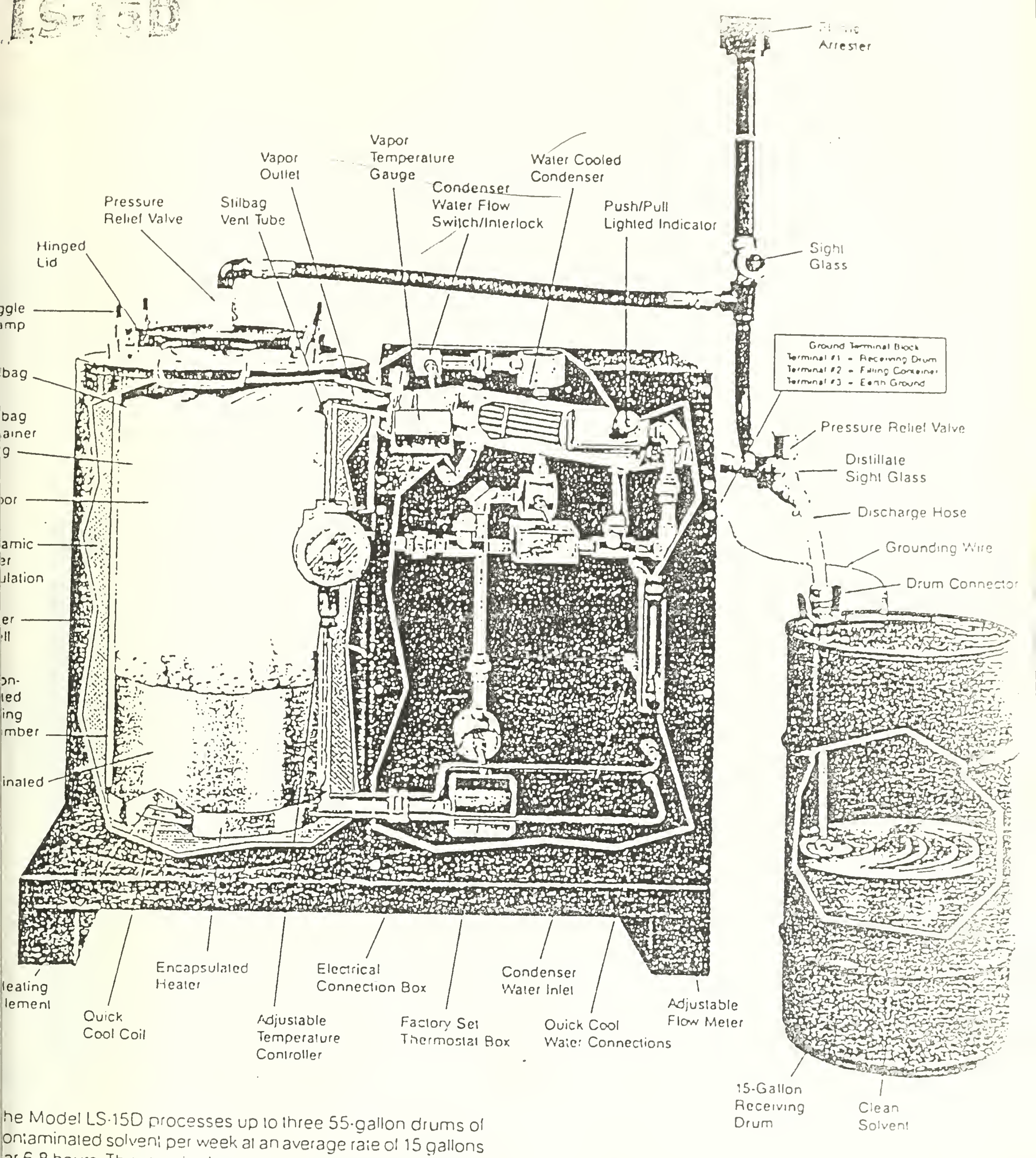
A unique vertical solvent pump and JetVac are immersed in a single reservoir. This assembly is used to create a vacuum within the distillation unit.

Solvent in the reservoir tank is circulated by the solvent pump through the high-velocity JetVac. This high-speed circulation produces a vacuum in the distillation unit. Cooling coils in the reservoir tank maintain solvent temperature. As additional solvent is reclaimed and cooled, it is gravity-fed from the vacuum unit to an approved customer-provided 15- or 55-gallon d...

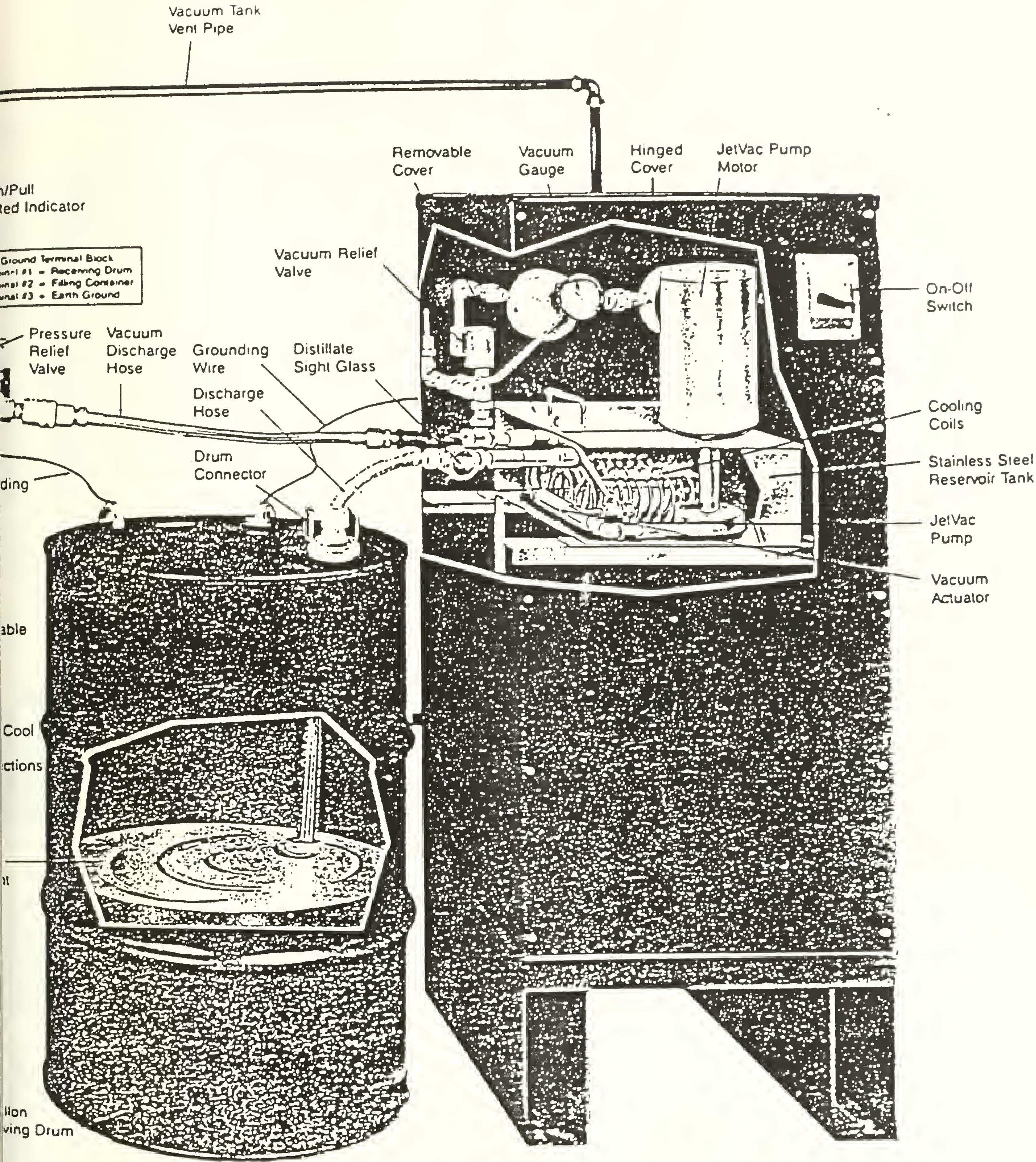
LS-15D



The Model LS-15D processes up to three 55-gallon drums of contaminated solvent per week at an average rate of 15 gallons per 6-8 hours. This standard atmospheric unit reclaims solvents with boiling points up to 320ºF. Solvents with boiling points up to 500ºF can be reclaimed with use of the JetVac attachment.



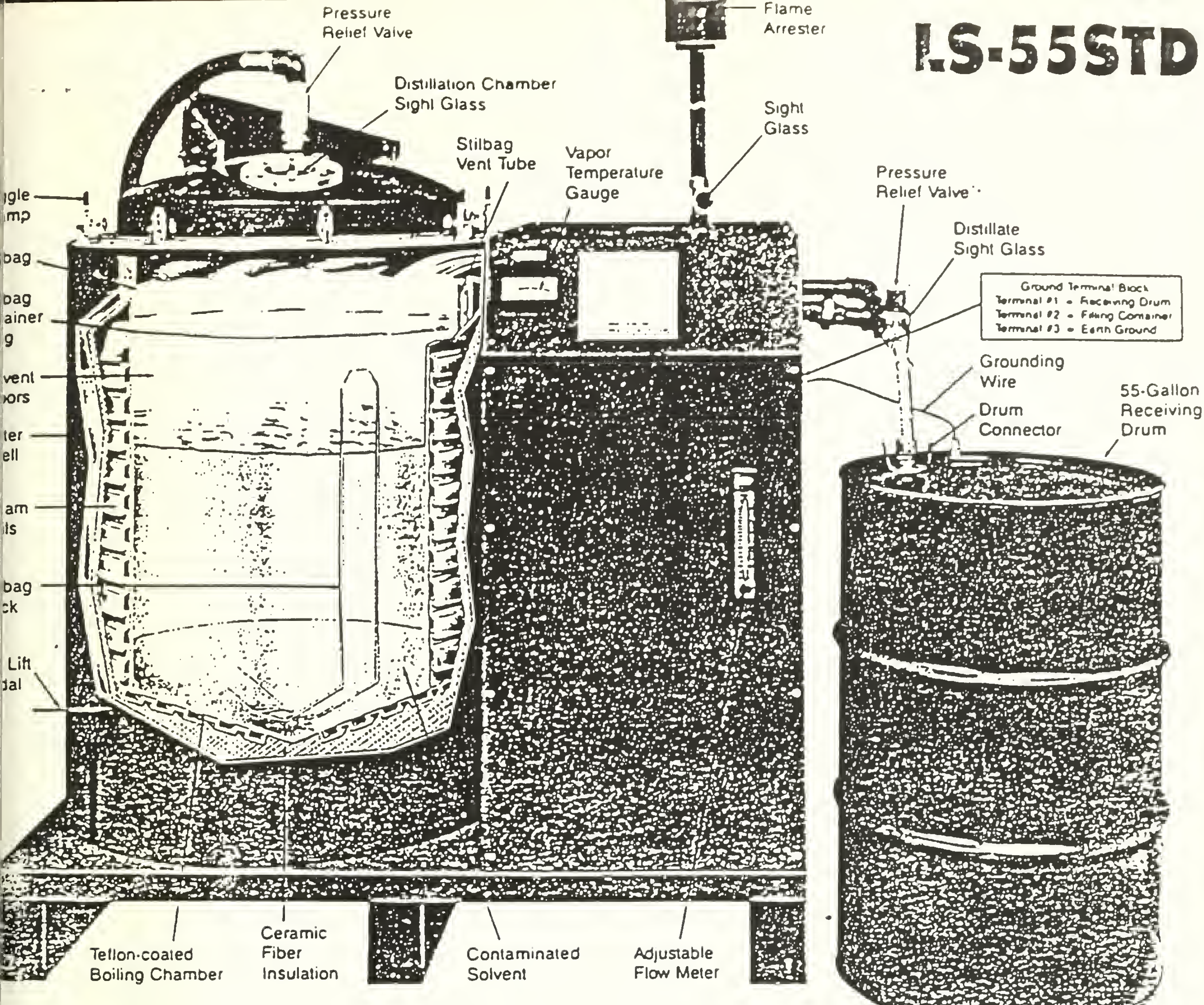
he Model LS-15D processes up to three 55-gallon drums of ontaminated solvent per week at an average rate of 15 gallons er 6-8 hours. This standard atmospheric unit reclaims solvents vith boiling points up to 320°F. Solvents with boiling points p to 500°F can be reclaimed with use of the JetVac ttachment.



JetVac Features

- Allows either vacuum or atmospheric distillation
- Minimal operator involvement
- Unique JetVac pump design
- Achieves up to 28 inches (71 cm) mercury vacuum
- Meets Class I, Division I, Group D (NEMA 7) standards
- Vacuum operation can begin at reclaimer unit start-up or after atmospheric distillation is in progress.
- Distillate discharges to drum at atmospheric pressure
- One-switch operation
- Easy-to-read vacuum gauge
- Fully grounded

LS-55STD



The Model LS-55STD processes up to twenty 55-gallon drums per week at an average rate of 110 gallons per 8-hour shift operating dual batches. This steam-heated unit reclaims solvents with boiling points up to 320°F and will accept the optional JetVac attachment for boiling points up to 500°F.

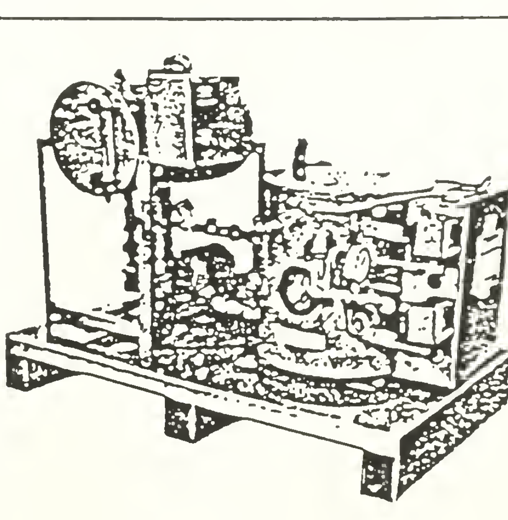
The Model LS55STD features a steam coil heating system contained within the boiling chamber walls providing 100% heat transfer area. Heat is transferred from the walls directly into the contaminated solvent. Utilizing in-plant steam or the optional pre-packaged steam boiler system, the LS-55STD operates with exceptional efficiency.

Optional Steam Boiler System

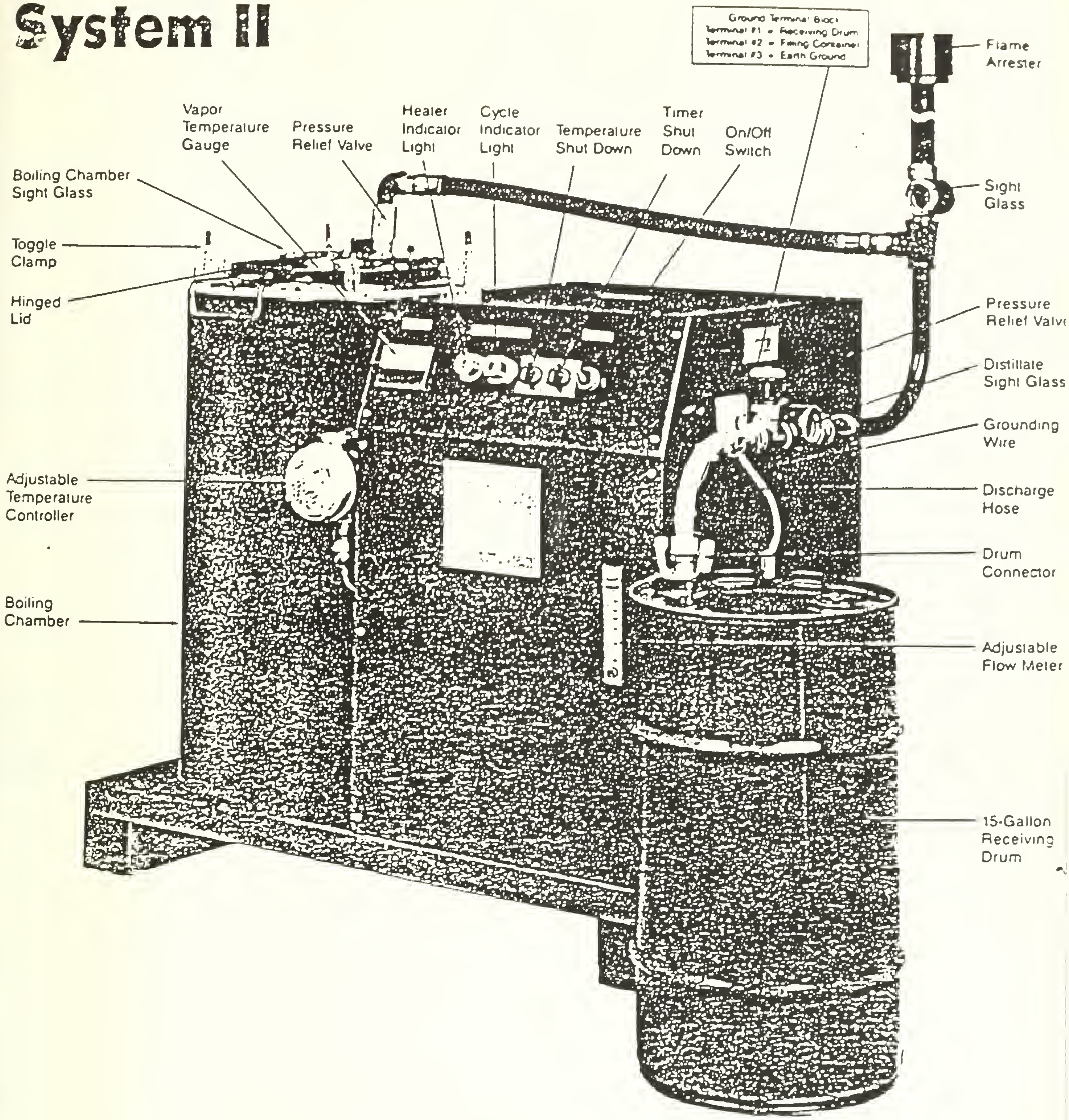
Finish Company offers a completely pre-packaged steam boiler system for LS-55STD applications where in-plant steam is not available. Consult Finish Company for specific utility requirements.

The system is pre-wired into a Finish Company control panel where the main power supply is connected. Two conduit lines are run between the boiler package and distillation unit to complete the electrical installation.

Note: The boiler system and control panel are not explosion-proof and must be mounted away from the Class I area as determined by NFPA or equal standards.



System II



System II is a completely automated version of the standard LS-15D and LS-55D units

Features

- Automated cycle completion selected by pre-determined temperature or time setting.
- At cycle completion, automatic cooling water quickly cools the boiling chamber to permit quick access and multiple shift operation.
- Quick cool cycle also maintains condenser water flow to insure any remaining vapors in vessel are condensed.
- Large viewglass for visual inspection of the distillation process through vessel lid.
- Console-mounted amber light indicates heater operation.
- System II unit will shut down at cycle completion without operator involvement.

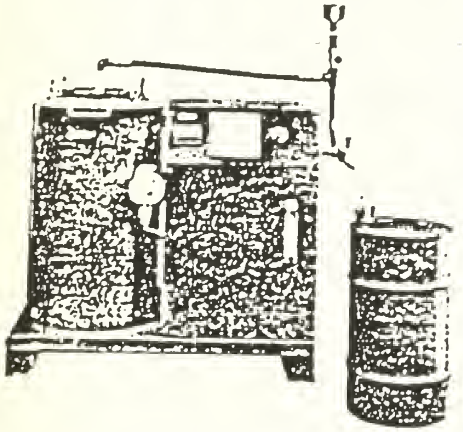
Specifications

Note: Attached to each LS Unit is a Stilmanual, which directs you to follow NFPA or equal standards for installation

LS-Jr.

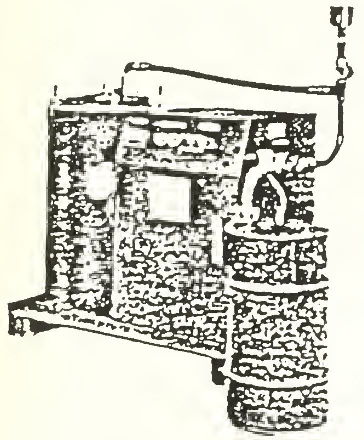
Process Rate	3-5 gal/shift	11.4-18.9 ltr/shift
Boiling Range	100 - 320ºF	38 - 160ºC
UTILITY REQUIREMENTS		
Condensing Water	1/8 - 1/4 gpm	.47 - .95 lpm
Cooling Water	—	—
Electricity	115V 1Ø 50/60 Hz .92 kw	
UNIT DIMENSIONS		
Length	29 in	737 mm
Width	24 in	610 mm
Height	19 in	483 mm
Weight	220 lbs.	100 kg

LS-15D



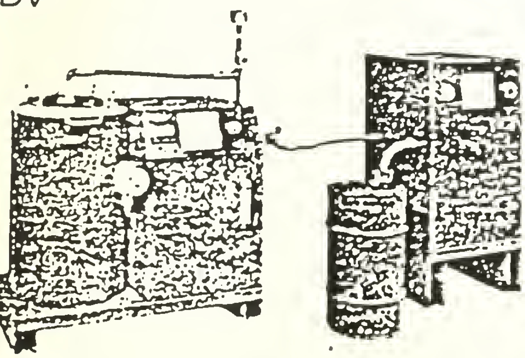
Process Rate	15 gal/shift	57 ltr/shift
Boiling Range	100 - 320ºF	38 - 160ºC
UTILITY REQUIREMENTS		
Condensing Water	1/4 - 1/2 gpm	.95 - 1.9 lpm
Cooling Water*	1 - 3 gpm	3.8 - 11.4 lpm
Electricity	115V 1Ø 50/60 Hz 1.65 kw	
	220V 1Ø 50/60 Hz 1.65 kw	
UNIT DIMENSIONS		
Length	51 in	1295 mm
Width	27 in	686 mm
Height	42 in	1067 mm
Weight	425 lbs.	193 kg

LS-15IID



Process Rate	15 gal/shift	57 ltr/shift
Boiling Range	100 - 320ºF	38 - 160ºC
UTILITY REQUIREMENTS		
Condensing Water	1/4 - 1/2 gpm	.95 - 1.9 lpm
Cooling Water*	1 - 3 gpm	3.8 - 11.4 lpm
Electricity	115V 1Ø 50/60 Hz 1.65 kw	
	220V 1Ø 50/60 Hz 1.65 kw	
UNIT DIMENSIONS		
Length	51 in	1295 mm
Width	27 in	686 mm
Height	42 in	1067 mm
Weight	565 lbs.	256 kg

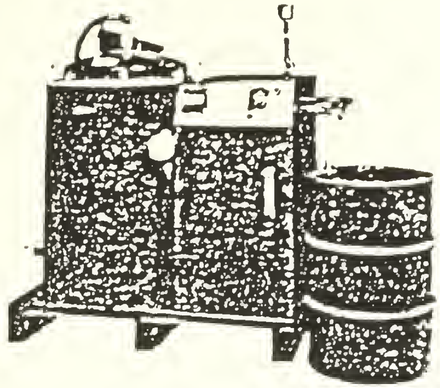
LS15DV



Process Rate	15 gal/shift	57 ltr/shift
Boiling Range	100 - 500ºF	38 - 260ºC
UTILITY REQUIREMENTS		
Condensing Water	3/4 - 1 gpm	2.8 - 3.8 lpm
Cooling Water*	1 - 3 gpm	3.8 - 11.4 lpm
Electricity	115V 1Ø 60 Hz 2.2 kw	
	220V 1Ø 60 Hz 2.2 kw	
UNIT DIMENSIONS		
Length	99 in	2515 mm
Width	27 in	686 mm
Height	48 in	1219 mm
Weight	740 lbs.	335 kg

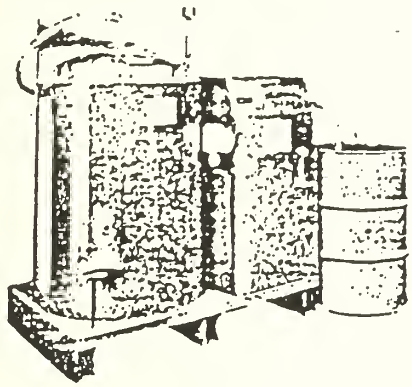
Note: Attached to each LS Unit is a Stilmanual, which directs you to follow NFPA or equal standards for installation.

LS-55D



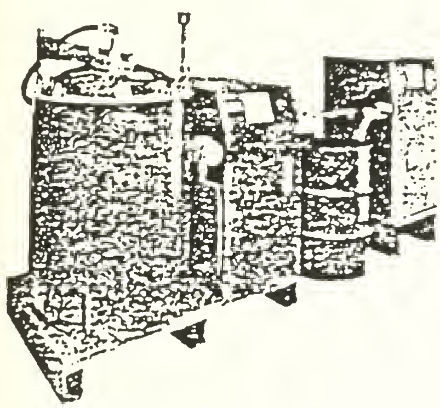
Process Rate	55 gal/ shift	208 ltr/shift
Boiling Range	100 - 320ºF	38 - 160ºC
UTILITY REQUIREMENTS		
Condensing Water	1 - 1½ gpm	3.8 - 5.7 lpm
Cooling Water*	2 -5 gpm	7.6 - 18.9 lpm
Electricity	220V 1Ø 50/60 Hz 6.2 kw	
UNIT DIMENSIONS		
Length	75 in	1905 mm
Width	40 in	1016 mm
Height	60 in	1524 mm
Weight	825 lbs.	374 kg

LS-55IID



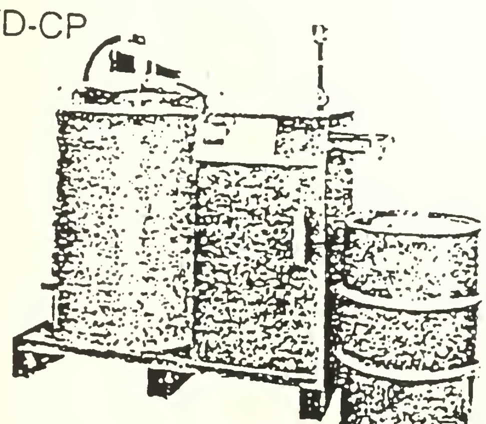
Process Rate	55 gal/ shift	208 ltr/shift
Boiling Range	100 - 320ºF	38 - 160ºC
UTILITY REQUIREMENTS		
Condensing Water	1 - 1½ gpm	3.8 - 5.7 lpm
Cooling Water	2 - 5 gpm	7.6 - 18.9 lpm
Electricity	220V 1Ø 50/60 Hz 6.2 kw	
UNIT DIMENSIONS		
Length	75 in	1905 mm
Width	40 in	1016 mm
Height	60 in	1524 mm
Weight	1140 lbs.	510 kg

LS-55DV



Process Rate	55 gal/ shift	208 ltr/shift
Boiling Range	100 - 500ºF	38 - 260ºC
UTILITY REQUIREMENTS		
Condensing Water	1½ - 2 gpm	5.7 - 7.6 lpm
Cooling Water*	2 - 5 gpm	7.6 - 18.9 lpm
Electricity	220V 1Ø 60 Hz 7.8 kw	
UNIT DIMENSIONS		
Length	131 in	3327 mm
Width	40 in	1016 mm
Height	60 in	1521 mm
Weight	1150 lbs.	522 kg

LS-55STD-CP



Process Rate	110 gal/ shift	416 ltr/shift
Boiling Range	100 - 320ºF	38 - 160ºC
UTILITY REQUIREMENTS		
Condensing Water	2 - 4 gpm	7.6 - 15.1 lpm
Cooling Water	N/A	N/A
Electricity	110V 1Ø 60 Hz .5 kw	
UNIT DIMENSIONS		
Length	80 in	2032 mm
Width	40 in	1016 mm
Height	64 in	1626 mm
Weight	1420 lbs.	644 kg

*optional use